Planning for Planetary Protection and Contamination Control: Challenges Beyond Mars

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Andrea Belz and James Cutts

Agenda

- Define the problem
- Planetary Protection and future Mars exploration
- Roadmap: Exploration beyond Mars
- Planetary Protection and Contamination Control concerns for:
  - Europa
  - Titan
  - Comets
- Conclusions and recommendations

Planetary Protection and In Situ Missions

- **Planetary Protection**: Set of measures to preserve the chemical environment of a target body for future life-detection exploration ("forward contamination").
- **Back contamination**: Protection of Earth from potential extraterrestrial contaminants in sample return missions.
- **COSPAR guidelines** set limits on the amount of biological material that a spacecraft may carry for life-detection missions.
- These guidelines are reflected in **NASA policy 8020.12C**.

As NASA pursues missions with in-situ life-detection capabilities to targets beyond Mars, it will be key to understand how to implement planetary protection measures in new environments.

Planetary Protection Planning

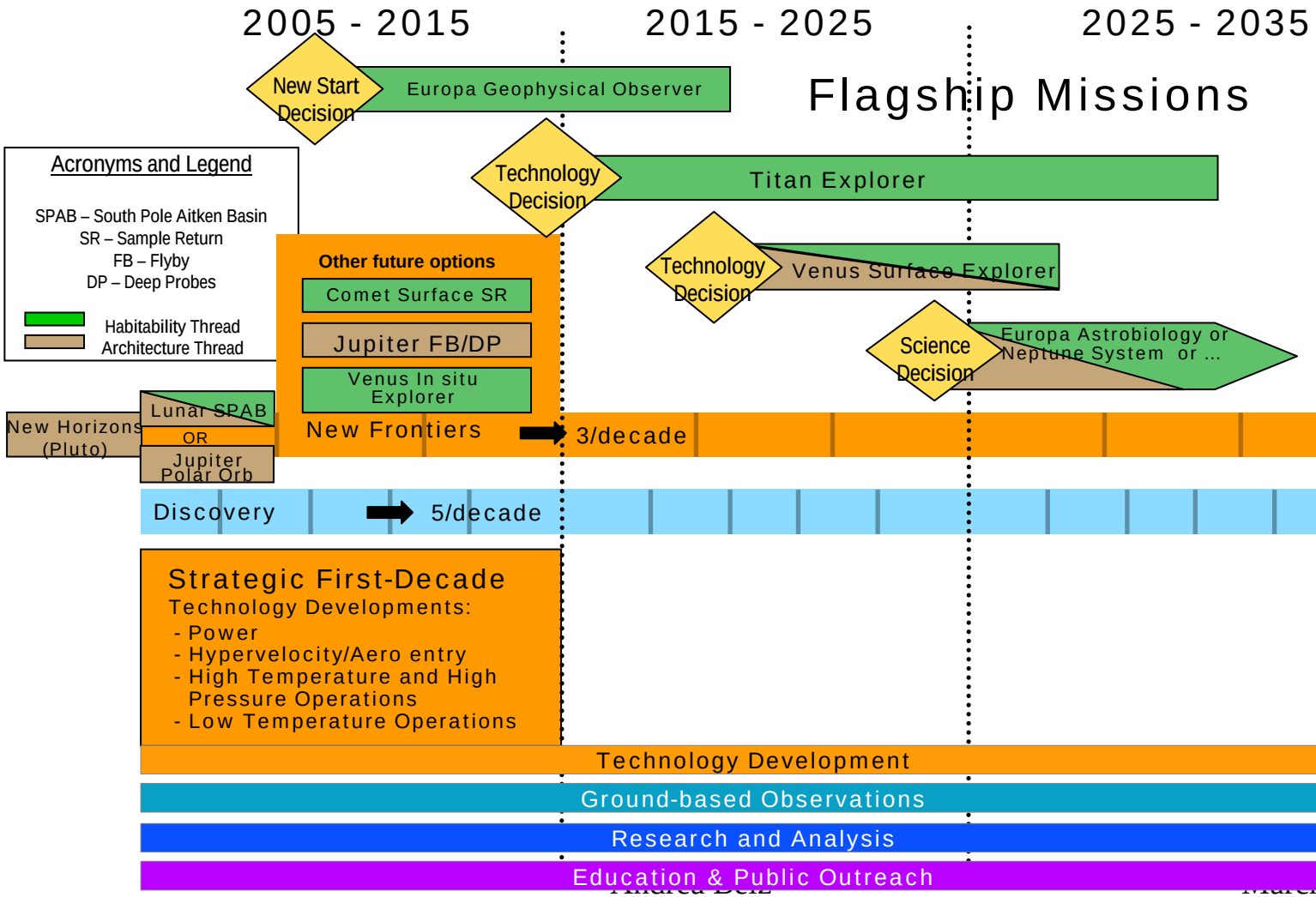
- **New COSPAR Policies (October 2002) and NASA Policy (April 2005)** established new controls for Mars and Europa and expanded the needs for spacecraft sterilization to account for:
  - Provisions for protection of potentially habitable regions on Mars
  - Provisions for protection of possible global ocean on Europa for both landed and orbital missions
  - The possibility of **terminal sterilization** of the entire spacecraft for both **life detection** and **non life detection** missions.
- **SSE Roadmap Priority Investments (May 2003)** did not include the impact of these new policies on planetary protection needs.
- **2003-2005**: JPL led an activity to develop a set of roadmaps describing planetary protection needs.

Mission Set

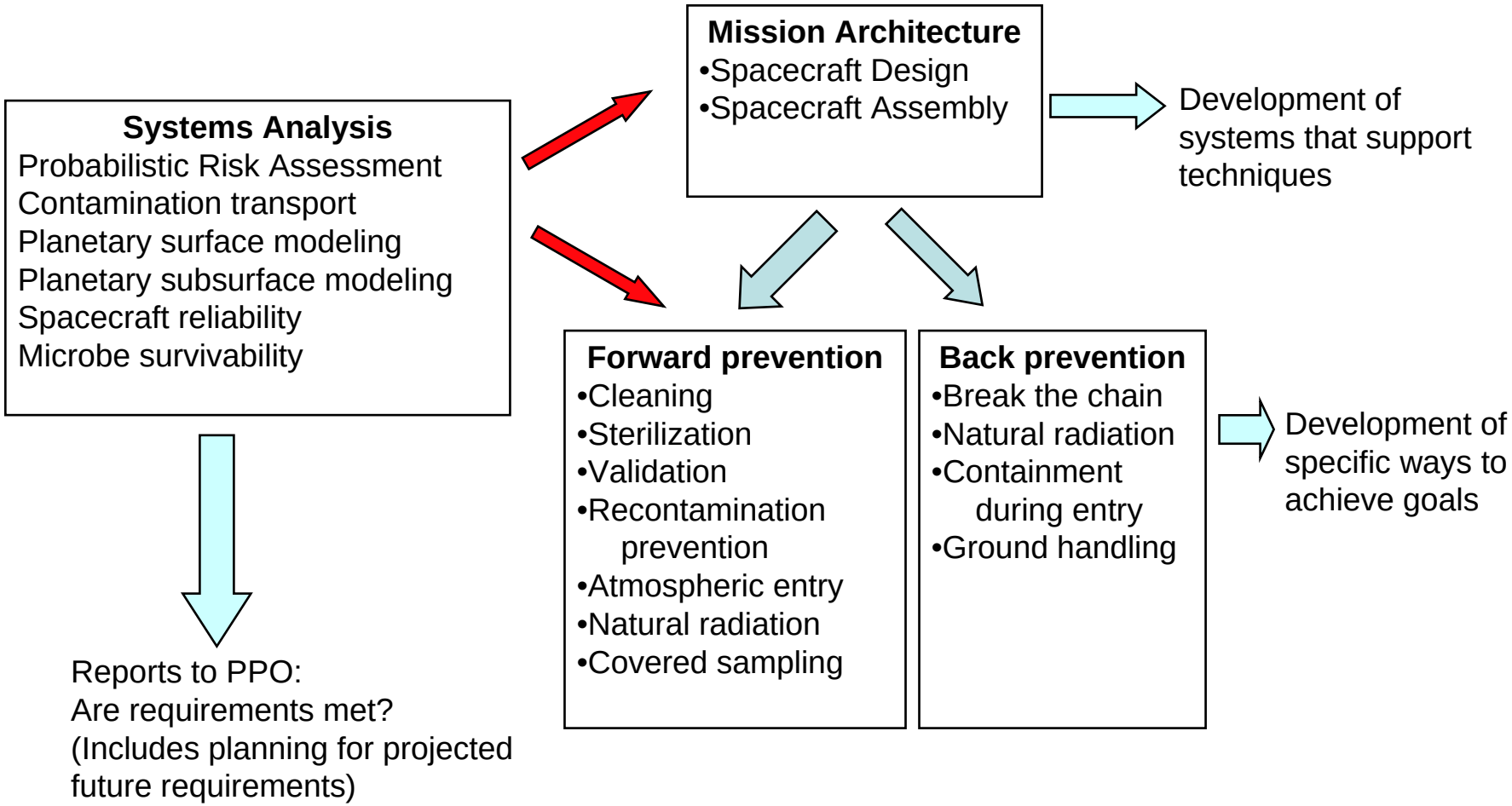
- SSE Design Reference Missions with anticipated strong PP requirements include:
  - Europa Orbiter
  - Europa Astrobiology Laboratory
  - Comet Surface Sample Return
  - Comet Cryogenic Sample Return
  - Titan Explorer
- For some targets, such as Titan, the requirements are not yet clearly defined, but some requirements are anticipated.

Science contamination control requirements present similar needs to planetary protection, and were therefore also partly addressed in this effort.

Solar System Exploration Strategic Road Map



Framework for PP and CC Planning



Historical implementation

- Current mission concepts present challenges that cannot be met simply by implementing the same techniques as historical missions.
- Consider historical orbiters:

	MGS	MCO	Odyssey	Galileo
Status	In orbit	Failed	In orbit	Ended
PP Categorization	**III**	**III**	**III**	**II**
PP Implementation				
Assembly	Class 100K	Class 100K	Class 100K	Class 100K
Probability of impact analysis	Yes	Yes	Yes	Yes
Option to raise orbit	Yes	N/A	Yes	No
Alternative solution employed	N/A	N/A	N/A	Disposal at Jupiter

Past Landed Missions to Mars: Examples of Implementation

	Viking	Pathfinder	MPL	MER	Beagle 2
Description	2 soft landers	1 airbag rover	1 soft lander/ 2 probes	2 airbag rovers	1 airbag lander
Status					
Landing	Success	Success	Fail	Success	Fail
Prime mission	Complete	Complete	NA	Complete	NA
Extended mission	Complete	Complete	NA	In progress	NA
Mass of landed elements	576 kg	800 kg	512 kg/3.6kg	1000 kg	50 kg
Science					
Life detection	Yes	None	None	None	No
Organics investigations	Yes	No	No	No	Yes
PP Categorization	**IVb***	**IVa**	**IVa**	**IVa**	**IVa**
Responsibility for implementation	JPL/Langley	JPL	JPL/ Contractor	JPL	ESA/Open University
PP and CC Implementation					
Cleaning					
Clean Room Assembly	100K	100K	100K	100K	10K
Cleaning by wipes (not to sterility)	Yes	Yes	Yes	Yes	Yes
Sterilization					
Hydrogen Peroxide	No	No	No	No	Some
Gamma Radiation	No	No	No	No	Some
DHMR: Components	Yes	Some	Some	Many	Some
DHMR: System level terminal cycle	Yes	No	No	No	No
Recontamination prevention					
Biobarrier architecture	Yes	No	No	No	Yes
Physical barrier	Bioshield	Aeroshell	Aeroshells	Aeroshell	Aeroshell
HEPA filter use	No	One	No	Many	No
Final estimated bioburden	30	0.3x10^5	3x10^5	2x10^5	<<3x10^5

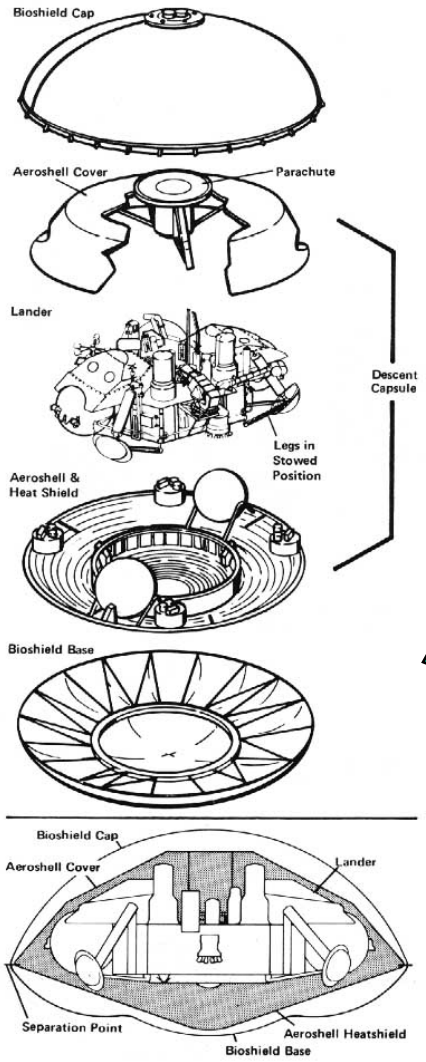
Future Mars exploration

- Phoenix (scheduled for launch in 2007):
  - Intended to sample icy soil below surface of northern pole
  - Sampling system will be sterilized, then enclosed and isolated during assembly, test, and launch operations (ATLO).
- Mars Science Laboratory (scheduled for launch in 2009)
  - Intended to explore habitability of surface
  - High Efficiency Particle Arrestor (HEPA) filters used to isolate regions of the spacecraft.
- Mars Sample Return (deferred)
  - Intended to be the first robotic sample return mission with substantial back contamination requirements
  - Sample handling and containment would be subject to stringent forward contamination control.

Planetary Protection and Mission Architecture

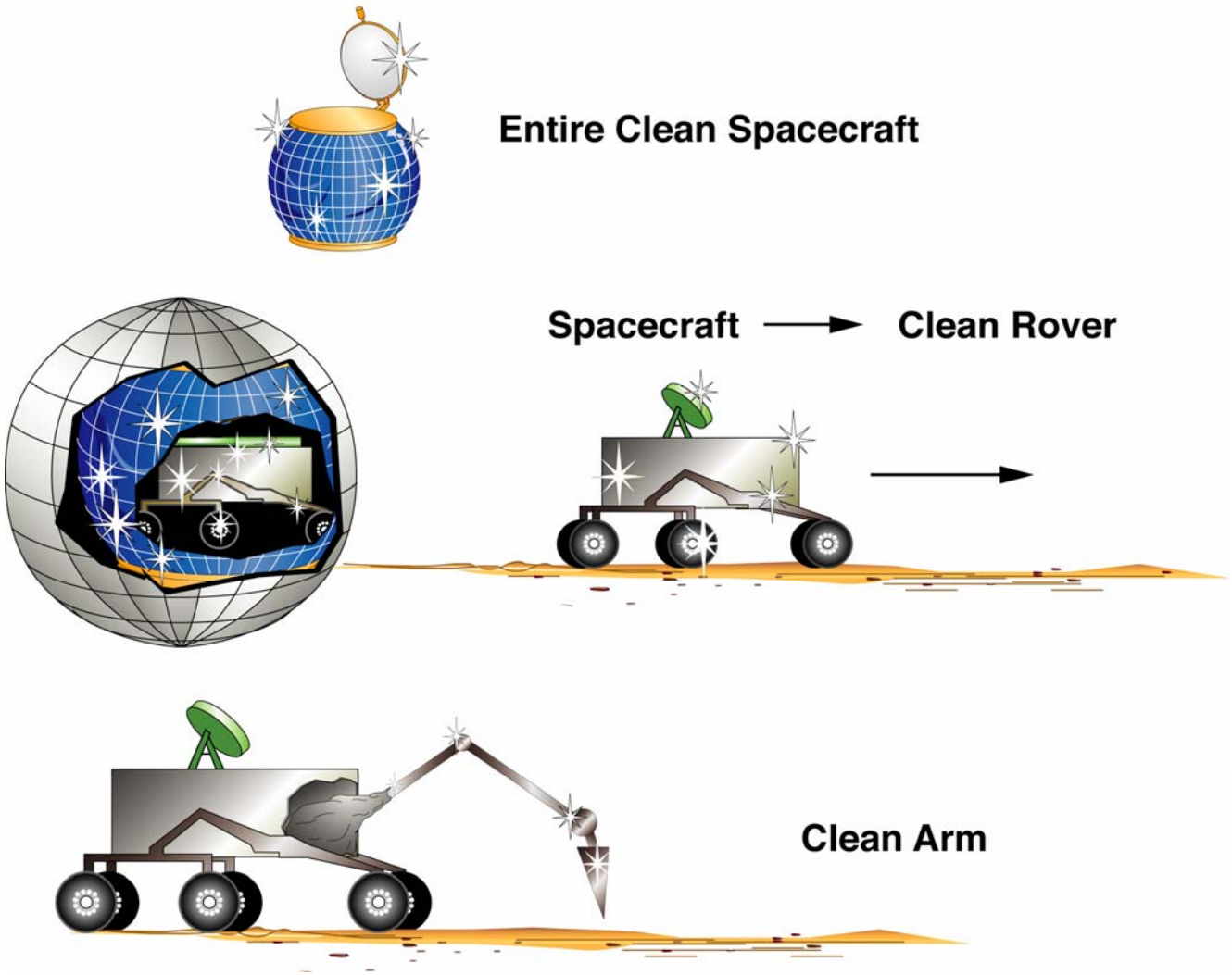
- To expand PP capabilities to other targets, need to include mission architecture considerations, not just “classical” PP methods of cleaning and heating.
- Many PP implementation techniques are closely linked with mission and spacecraft design and require integration at the outset, such as:
  - Biobarrier design and deployment (including challenges in ATLO)
  - Covered sampling tool designs
  - Sterilization options after launch:
    - Atmospheric entry at Mars
    - Radiation at Europa
- To be effective, such measures must be considered from the earliest mission design.

Mission Architecture: Viking Bioshield Model for Recontamination Prevention



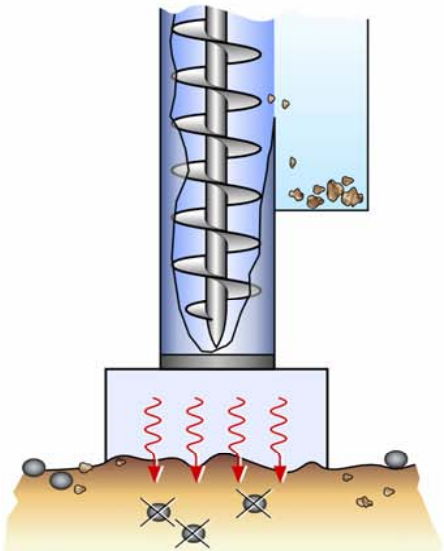
- Bioshield base jettisoned shortly after start of cruise phase.
- Separated from orbiter as part of process of deploying the aeroshell (with lander inside).

Mission Architecture: Recontamination Prevention with Biobarriers

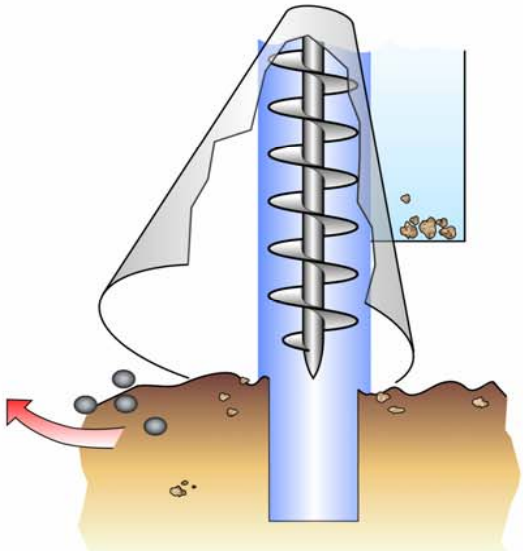


Mission Architecture: Forward Protection in Covered Sampling Tools

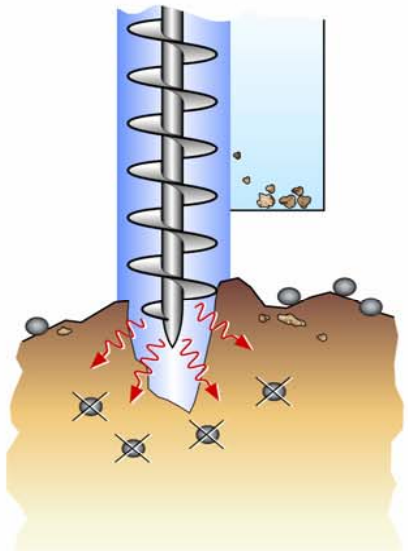
Sterilizing Hood



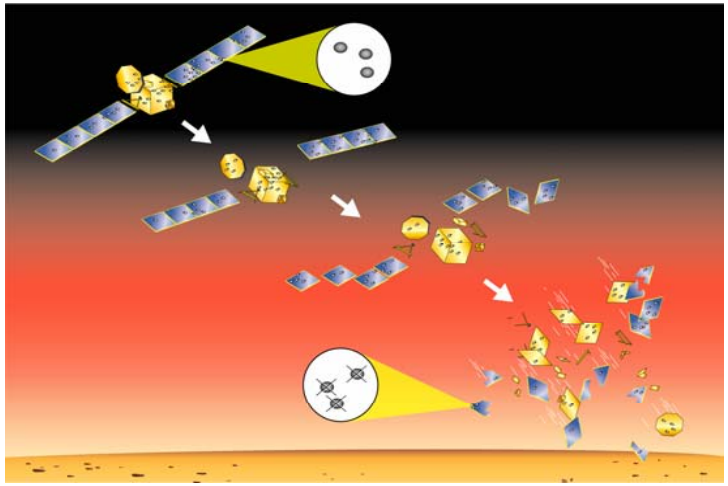
Covered Scraper



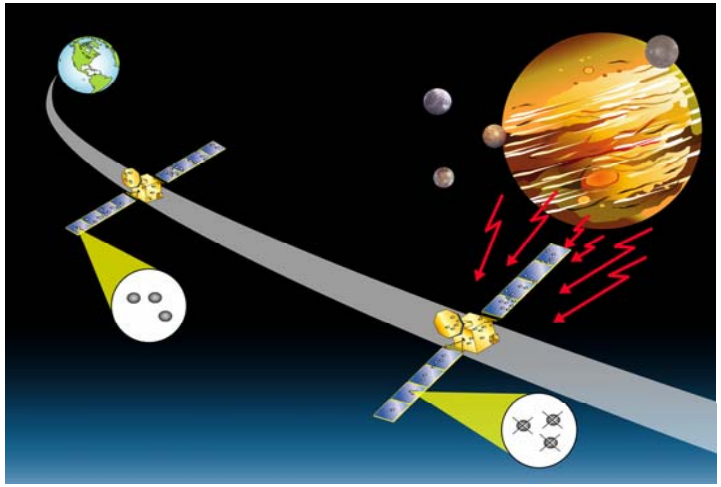
Heated Door



Mission Architecture: Forward Protection by Post-launch Sterilization



Atmospheric entry at Mars



Radiation at Europa

- May provide cost-effective additional sterilization
- Dependent on modeling
- May be more effective if integrated into mission design